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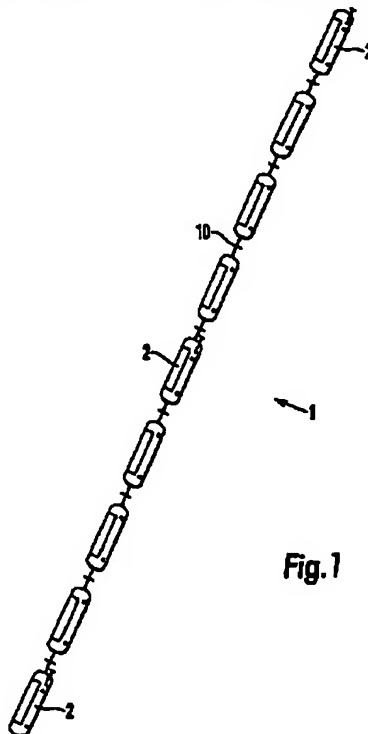
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(54) Abstract Title

**Resiliently coupled submersible vehicles**

(57) A submersible vehicle 1 comprises a plurality of rigid submersible vessels 2 coupled by resilient couplings 10 adapted to transmit pulling and braking forces between adjacent rigid submersible vessels. The couplings may be adapted to limit the maximum angle between the axes of adjacent vessels to 10°, 5° or 2.5°. Some of the submersible vessels may include propulsion means (4, Fig 2) with more than four propellers per vessel. Each submersible vessel may have a length within the range 80m to 200m. The resilient coupling may comprise a coupling member (12, Fig 4) secured at each end by means of a resilient member (11, Fig 4) to the two adjacent vessels or the coupling may comprise a ball and socket arrangement (Fig 5).



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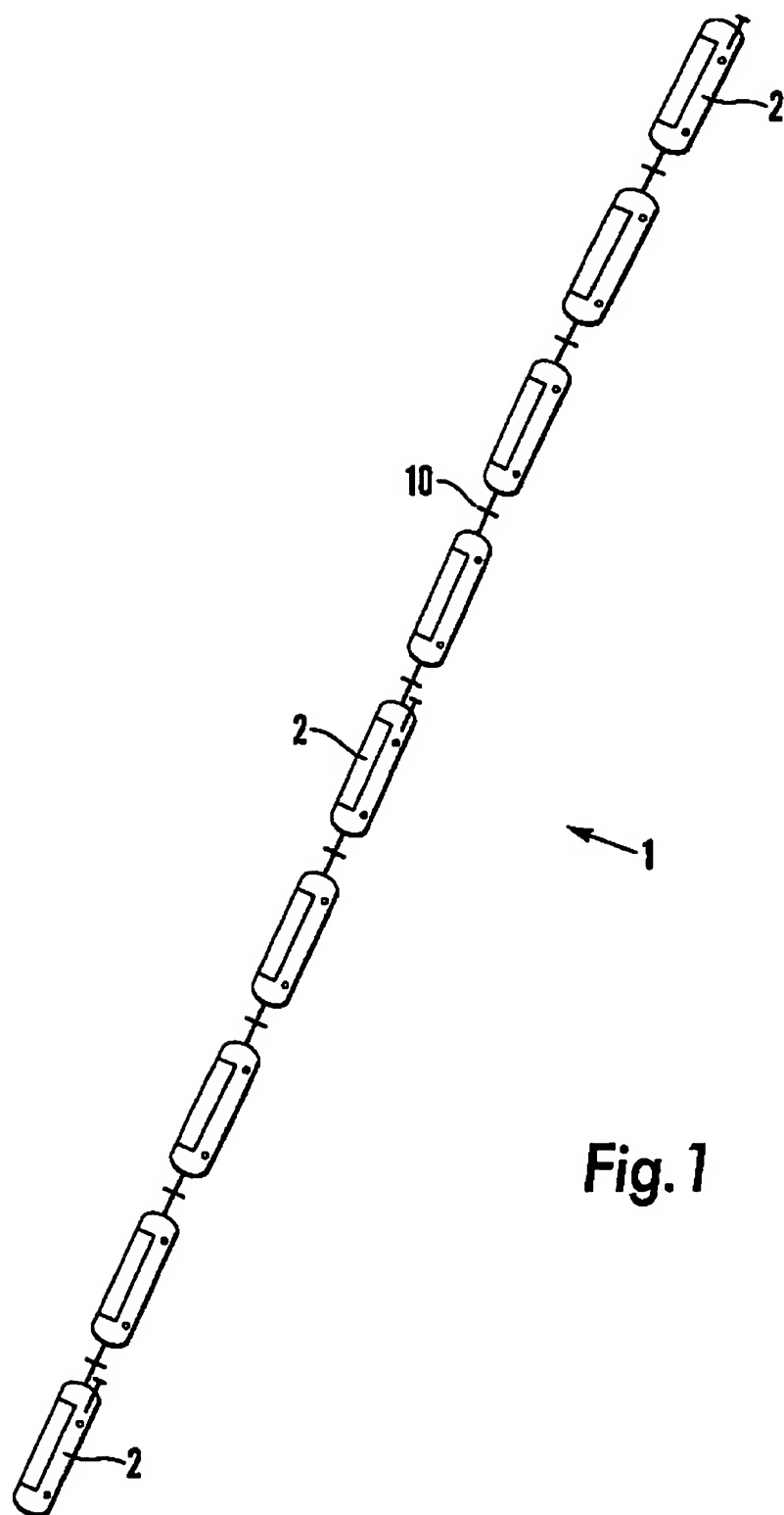


Fig. 1

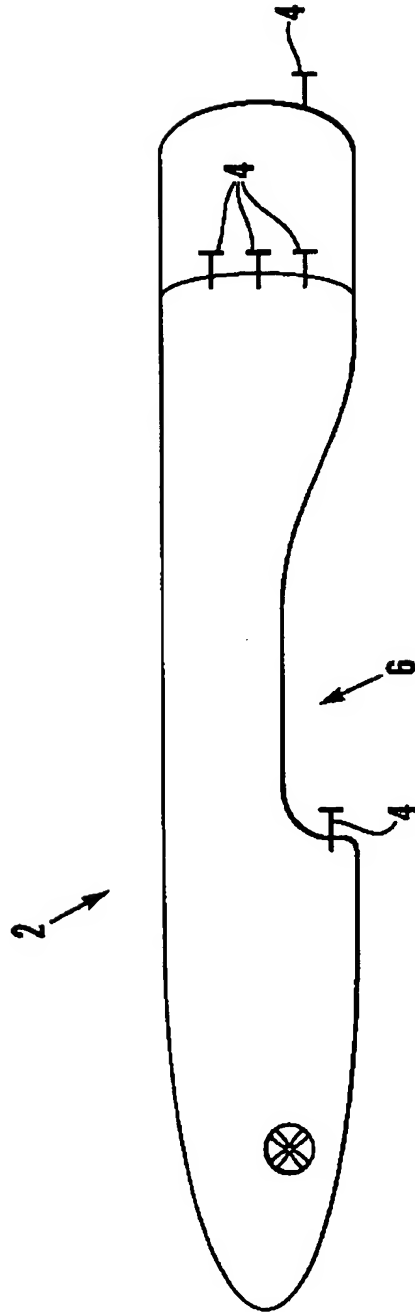


Fig.2

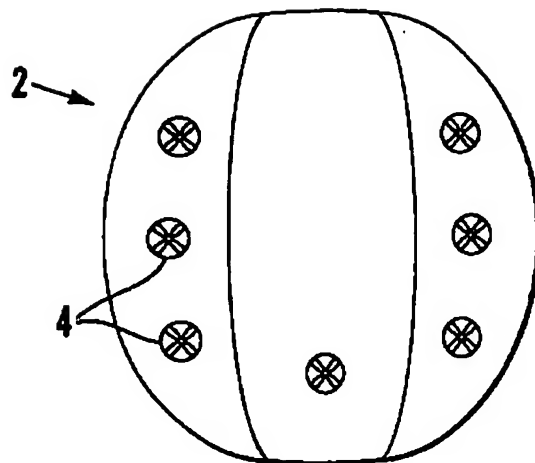


Fig. 3

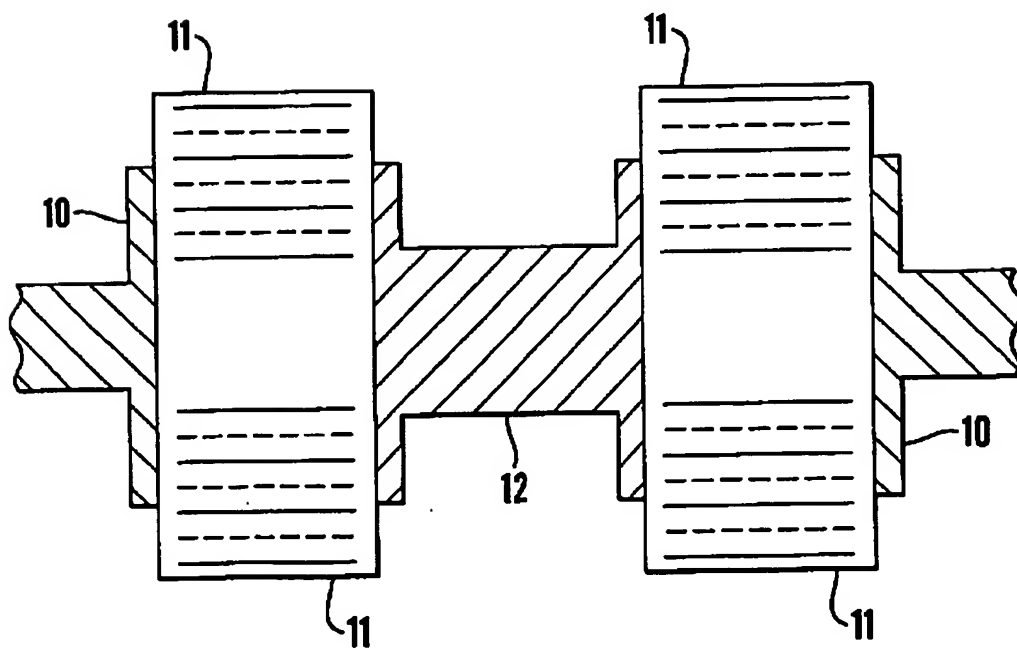


Fig. 4

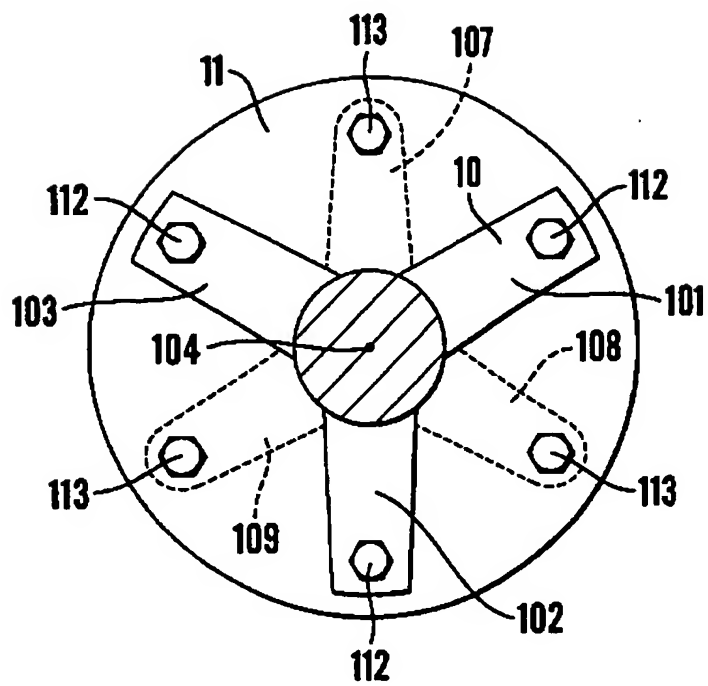


Fig. 4A

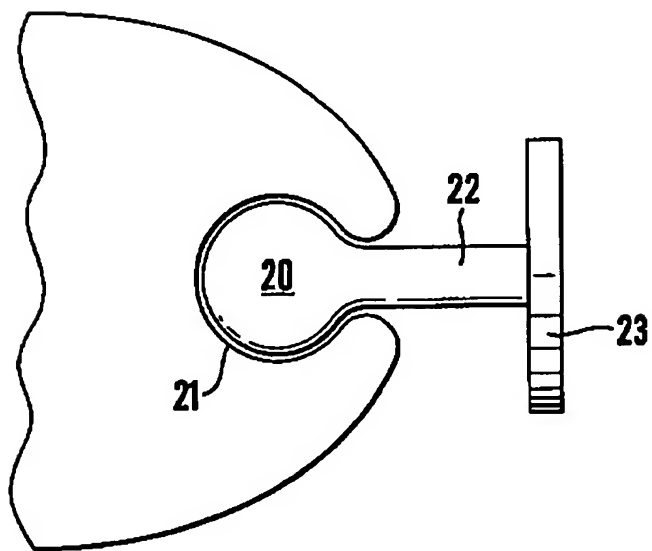


Fig. 5

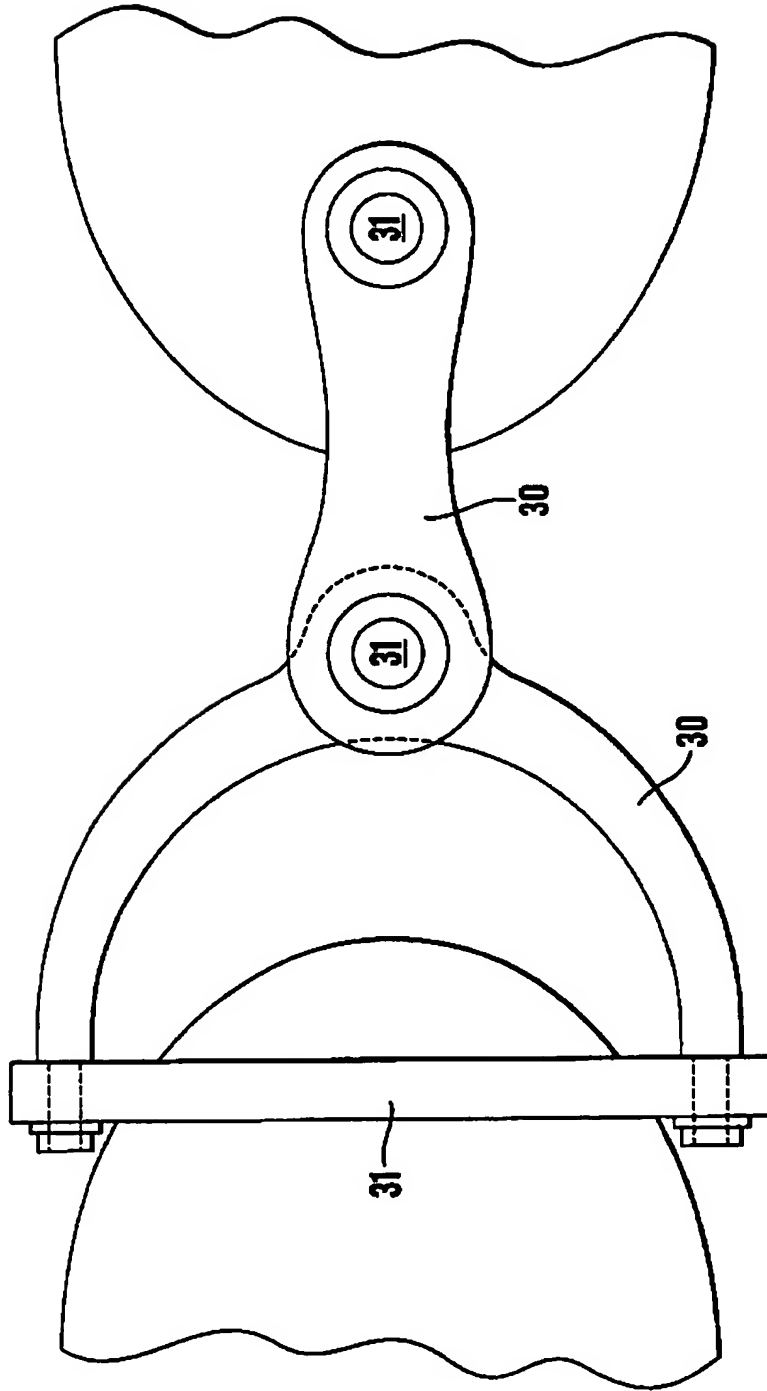


Fig.6

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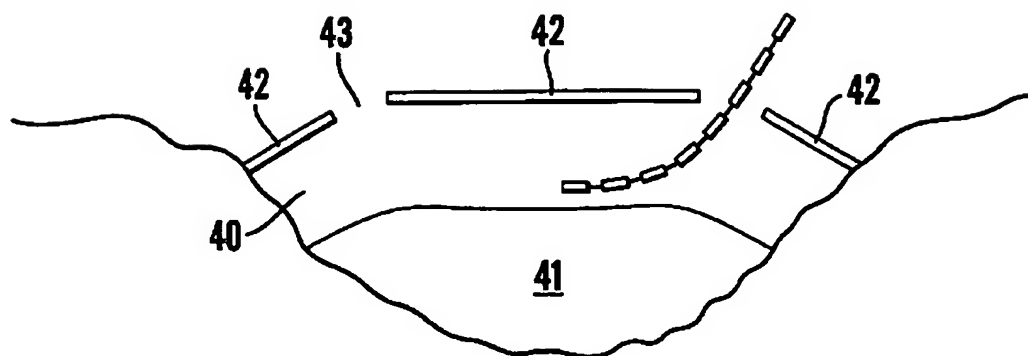


Fig. 7

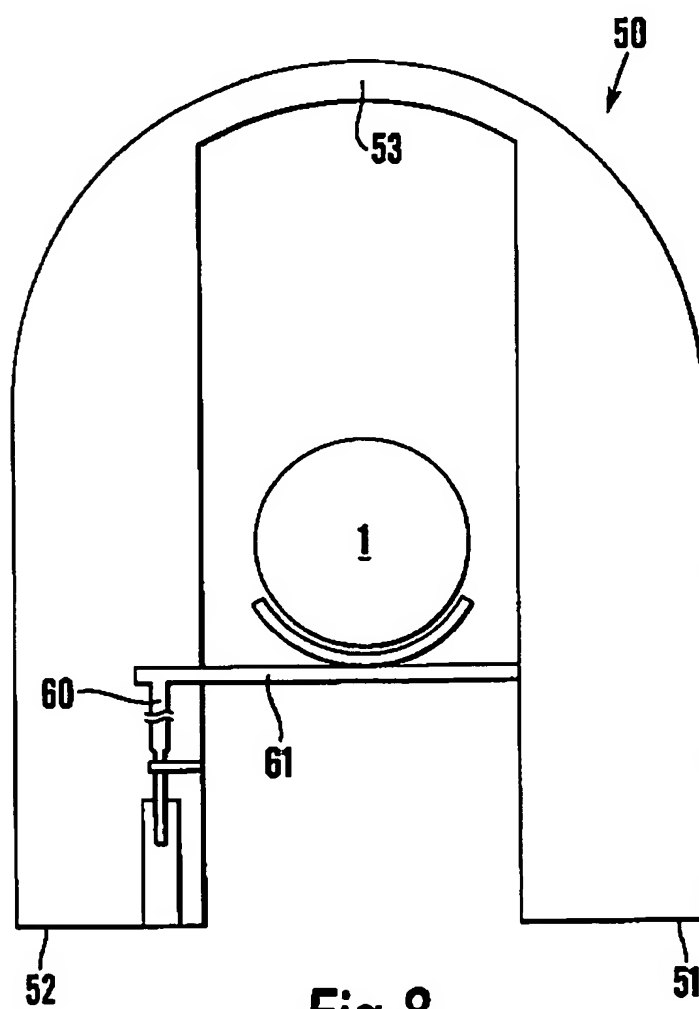


Fig. 8



## SUBMERSIBLE VEHICLE

This invention relates to a submersible vehicle.

5 According to the invention there is provided a submarine comprising a plurality of rigid submersible vessels coupled by resilient couplings.

Hitherto it has been difficult to provide a large submarine. When submerged the submarine which is essentially a tube with the ends capped is subject to external  
10 hydrostatic pressure. To prevent crushing of the tube the walls must be thick. The greater the diameter of the tube the thicker the walls need to be. A smaller diameter tube can be thinner but of course needs to be longer to have the same volume. While the same amount of material or indeed slightly for the same internal volume more may be required with the smaller tube, it is much easier to manipulate and form thin  
15 plate than thick. However a large volume submarine of small diameter will be very long since halving the diameter of a tube reduces its volume by a factor of four. A very long thin conventional submarine would be difficult to control.

The present invention provides a submarine characterized in that it comprises a  
20 plurality of rigid submersible vessels coupled by resilient couplings.

This provides the advantage of a small submarine (greater strength without the disadvantage of unwieldy handling of a long narrow submarine).

25 Whilst the invention may only include two submarines coupled together, we envisage that in practice a larger number of submarines may be connected together to provide the major benefit of the invention.

30 However, in coupling two or more submarines together, problems have to be overcome. Firstly, if the submarines were simply connected to one another by means of a cable or hawser, then whilst this may have limited use where only the front submarine is driven, there are difficulties when the submarines slow down and come

to a halt in that there will be nothing to stop the rear submarines hitting the forward submarines, and perhaps the submarines ending up "jack-knifing" into a disorganized array both in the horizontal and the vertical direction. It is therefore necessary to resist this.

5

The present invention provides a submersible vehicle characterized in that it comprises a plurality of rigid submersible vessels coupled by resilient couplings adapted to transmit pulling and braking forces between adjacent rigid submersible vessels

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Embodiments of the invention will be described by way of non-limiting example with reference to the accompanying figures of which:

Fig. 1 is a schematic side elevation of a vehicle;

15

Fig. 2 is a schematic side elevation of a vessel;

Fig. 3 is a schematic side end elevation of the vessel of Fig. 2;

Fig. 4 is a schematic cross-section of a first coupling;

Fig. 4A is an end view of an alternate version of the first coupling of Fig. 4

Fig. 5 is a schematic scrap view of a second coupling;

20

Fig. 6 is a schematic partially cutaway view of a third coupling;

Fig. 7 is a plan view of a harbour; and

Fig. 8 is a schematic cross-section of a floating harbour.

25

Vehicle 1 comprises a plurality of rigid pressure vessels forming submarine vessels connected together as will be described hereinafter. At least some vessels 2 are provided with propulsion means to drive the vessel, for example, by means of propellers, the remainder of the vessels 3 not including propulsion means. Typical dimensions for those vessels 2 which include propulsion means are 80m - 200m, preferably 100m or 150m length, and for those vessels 3 which do not include propulsion means, 50m - 100m, preferably 75m length; in each case the outer diameter may be for example from 2m to 10m, preferably 7m. In the embodiment of

30

Fig.1 the front and rear vessels and one other include propulsion means, the other

vessels having, save as hereinafter described, no propulsion means. At least some of the vessels may have means for adjusting attitude. This may comprise one or more of rudders, hydroplanes, side thrusters and ballast tanks. Those skilled in the art will have little difficulty in devising other suitable means for adjusting attitude.

5

Those skilled will have little difficulty in devising suitable power sources. In many cases the ultimate drive will be by electric motor (although this is not essential). Those skilled will have little difficulty in devising suitable sources of electricity. Non-limiting examples include batteries, electric generators drive by an internal combustion engine and nuclear piles.

10

Vessels 2, 3 are rigid pressure vessels broadly similar to the pressure vessel of a conventional submarine rather than a flexible semi-submersible vessel as described in GB 883 813.

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In the embodiment illustrated in Fig. 2 and 3, vessel 2 is of the order of 150m long. As can be seen from Fig. 3 a plurality of propellers 4 are fitted toward the stern of the vessel. A plurality of propellers are in this embodiment provided part way along the vessel 2 in recess 6. While a plurality of propellers and hence in some cases a plurality of drive motors results in increased weight, manoeuvrability may be increased and incapacity of one propeller will have little effect upon the speed or manoeuvrability of the vessel.

20

Many embodiments of the invention will be manned. Manning may be by passengers and/or crew. Life support systems and accommodation may thus be required. Windows may be provided.

25

In the invention a plurality of joined submarine vessels are provided. A coupling 10 is provided between adjacent vessels which may transmit pulling and braking forces between them. A flexible non-resilient coupling will have a tendency to 'jack-knife'.

30

An example of a suitable resilient coupling is illustrated in Fig. 4. A base plate 10 is provided at the front and rear of each vessel 2, 3 generally on the axis of the vessel 2,

3. A cylinder, or preferably an annulus 11 of resilient matter, for example, rubber is mounted on the base plate 10. Each base plate 10 is connected by adhesive or by bolts to one side face of the respective annulus 11. A coupling plate 12 is secured by adhesive or bolts to the second side face of each annulus 11 to form a coupling. The attachment could be achieved by bolts (not shown) passing through holes in the base plate 10, resilient matter 11 and coupling plate 12.

The coupling of Fig. 4 allows two submarines connected by such coupling to move such that their axes can move at a slight angle to one another to a limited extent. This allows the two submarines to be able to absorb different sideways and up-and-down forces applied to them, for example, during a turning maneuver or by currents, but maintains them generally in a co-axial alignment so that braking forces can be transmitted effectively. The maximum angle between adjacent vessels 2, 3 will be limited to a maximum of  $10^{\circ}$ , preferably  $5^{\circ}$ , preferably still  $2\frac{1}{2}^{\circ}$ , the exact angle depending on the length of each vessel and other factors. The coupling allows both pulling and braking forces to be transmitted between adjacent submarines.

Fig. 5 shows a further suitable resilient coupling in which a ball 20 is received in a socket 21 of the vessel. Stalk 22 attached to ball 20 is of resilient material. Stalk 22 terminates in flange 23 which need not be resilient material. A coupling of a first vessel is bolted by flange bolts 24 to a coupling of a second vessel.

Whilst the arrangement as shown in Fig. 5 will allow for transmission of pulling forces between two adjacent submarines, the use of braking forces will cause the submarines to "jack-knife" unless there is provided in the coupling resistance to angular deflection between the axes of the two adjacent submarines. This may be provided by, for example, a very tight fit between the ball 20 and socket 21 or by providing between the ball and socket resilient material, for example, rubber, which is bonded to the ball and socket and which flexes to allow the ball and socket to move slightly with respect to one another or by a physical detent restricting deflection. The coupling of Fig. 5 allows two submarines connected by such coupling to move such that their axes can move at a slight angle to one another to a limited extent. The

maximum angle between adjacent vessels 2, 3 will be limited to a maximum of  $10^{\circ}$ , preferably  $5^{\circ}$ , preferably still  $2\frac{1}{2}^{\circ}$ , the exact angle depending on the length of each vessel and other factors. This allows the two submarines to be able to absorb different sideways or up-and-down forces applied to them, for example, during a turning manoeuvre or by currents, but maintains them generally in a co-axial alignment. The coupling allows both pulling and braking forces to be transmitted between adjacent submarines.

Fig. 6 shows a coupling comprising a yoke 30 pivotally mounted to each vessel by pivot pin 31. Yokes 30 of adjacent vessels are joined by coupling pin 31. Preferably coupling pin 31 is substantially vertical to allow easy fitment and removal.

Whilst the arrangement as shown in Fig. 6 will allow for transmission of pulling forces between two adjacent submarines, the use of braking forces will cause the submarines to "jack-knife" unless there is provided in the coupling resistance to angler deflection between the axes of the two adjacent submarines. This may be provided by, for example, a very tight fit between the yoke 30 and pivot pin 31 or by providing between the yokes and pins a resilient material, for example, rubber, which is bonded to them and which flexes to allow the yokes to move axially slightly with respect to one another (or by physical detents). The maximum angle between adjacent vessels 2, 3 will be limited to a maximum of  $10^{\circ}$ , preferably  $5^{\circ}$ , preferably still  $2\frac{1}{2}^{\circ}$ , the exact angle depending on the length of each vessel and other factors.

In an alternative arrangement of the resilient coupling of Fig. 4, the base plate 10 may be shaped so as to provide a number of equiangular spaced fingers 101, 102, 103 extending away from the axis 104 of the base plate 10. As a typical example there may be provided three equiangularly disposed fingers. Similarly the plate 106 of the coupling plate 12 which is to be secured to the annulus 11 may comprise a similar number of equiangularly radially disposed fingers 107, 108, 109 and the configuration is such that the fingers of the coupling plate 12 and the fingers of the base plate 10 are radially displaced from one another. Thus a respective bolt 112 may be passed through the annulus 11 to couple each finger of the base plate 10 to the annulus 11,

and similarly bolts 113 may pass through the annulus 11 to couple the fingers of the coupling plate 12 to the annulus 11. In this way the annulus 11 may flex between adjacent fingers and this allows for a resilient coupling. Such an arrangement is illustrated in Fig. 4A. The maximum angle between adjacent vessels 2, 3 will be limited to a maximum of  $10^{\circ}$ , preferably  $5^{\circ}$ , preferably still  $2\frac{1}{2}^{\circ}$ , the exact angle depending on the length of each vessel and other factors.

Various other couplings may be devised but the preferred features of them are that there is provided limited resilient axial displacement of adjacent submarines, and there is the ability to transmit both braking and pulling forces between the submarines.

Motion sensors in the vessel connected to a computer system may be used somewhat along the lines of 'fly-by-wire' systems provided in aircraft to maintain the submarines in suitable alignment.

The submarine of the invention may be very long: lengths of 1200m are envisaged. Fig. 7 illustrates one way in which the submarine may be docked. Bay 40 is provided with landing area 41 and breakwaters 42. Breaks 43 in breakwaters 42 allow the submarine to leave and depart the landing area in an arcuate fashion.

The length of the submarine is such that a floating offshore platform may be desirable. Goods and passengers could be transhipped at this point or vessels could be coupled together to generate a submarine.

Fig. 8 illustrates such an arrangement. Floating harbour 50 comprises keels 51, 52 which may be provided with buoyancy tanks, anchors and/or motive power. Keels 51, 52 are joined for example by bridging member 53. Channel 54 is defined by the keels and bridging member. Submarine 1 is receivable in the channel and may be moored to the floating harbour. Mooring may be by conventional means such as cable.

In some embodiments of the invention at least one upwardly extending hydraulic ram 60 is provided together with means for actuating it. Support member 61 such as a cradle having an upper surface profiled to fit the lower surface of the submarine. Actuation of ram 60 allows the cradle to engage and disengage the submarine thereby allowing mooring of the submarine or vessel or even lifting of the submarine or vessel from the sea.

In some embodiments a detent mechanism is provided on the ram. This may, for example comprise a member with a plurality of holes movable relative to a pin with one of the member and pin being movable with the cradle and the other fixed. When the cradle is in the desired position the detent can be engaged. Pressure can then be released from the hydraulic system.

Those skilled in the art will have no difficulty in devising modifications.

**CLAIMS**

1. A submersible vehicle characterized in that it comprises a plurality of rigid submersible vessels coupled by resilient couplings adapted to transmit pulling and braking forces between adjacent rigid submersible vessels  
5
2. A submersible vehicle as claimed in claim 1 wherein said coupling is adapted to limit the maximum angle between the axes of adjacent submersible vessels to  $10^{\circ}$ .
- 10 3. A submersible vehicle as claimed in claim 1 wherein said coupling is adapted to limit the maximum angle between the axes of adjacent submersible vessels to  $5^{\circ}$ .
4. A submersible vehicle as claimed in claim 1 wherein said coupling is adapted to limit the maximum angle between the axes of adjacent submersible vessels to  $2\frac{1}{2}^{\circ}$ .  
15
5. A submersible vehicle as claimed in claim 1 wherein some of the rigid submersible vessels include propulsion means.
6. A submersible vehicle as claimed in claim 1 wherein the vessels including propulsion means are each provided with more than four propellers.  
20
7. A submersible vehicle as claimed of claim 1 wherein each submarine vessel has a length in the range 80m to 200m.
- 25 8. A submersible vehicle as claimed in claim 7 wherein some of the submarine vessels are 100m to 150m in length.
9. A submersible vehicle as claimed in claim 1 wherein the resilient coupling comprises a coupling member secured at each end by means of a resilient member to  
30 the two adjacent vessels.



10. A submersible vehicle as claimed of claim 1 wherein the resilient coupling comprises a ball and socket arrangement.